Influence of Physiological Constraints on a Subject-specific BSIP Calibration

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INFLUENCE OF PHYSIOLOGICAL CONSTRAINTS ON A SUBJECT-SPECIFIC BSIP CALIBRATION

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INTRODUCTION

Calibration of body segment inertial parameters (BSIP) is crucial in biomechanical studies. To avoid strenuous protocols, identification methods based on rigid body dynamics laws have been proposed [2,3]. Thanks to a motion capture system and force platforms, these methods optimize BSIP by minimizing errors in the equations of motion. These errors arise from estimated BSIP but also from kinematics and force plate measurements that may introduce overfitting in the calibration. To prevent this, [3] added physiological constraints in the calibration. On one case study, the goal of this current work is to analyze the influence of added physiological constraints in a BSIP calibration on results. The different calibration results are compared to the widely used anthropometric data proposed by [1].

METHODS

For this study, one male participant (183 cm, 80kg) performed a range of motion-type motion which activates sequentially each degree of freedom. 47 motion capture markers were placed on standardized anatomical landmarks and captured thanks to a Vicon® motion capture system (125 Hz). Two force platforms (1000 Hz) were used to access external forces applied on each foot. The motion is reconstructed thanks to a whole body model. Then, the BSIP calibration method consists in minimizing the dynamic residuals as proposed by [2]. To improve the results consistency, each limb is assimilated to a stadium solid [4]. So, the calibration finds the better stadium solid characteristics of each limb to minimize the dynamic residuals.

Three different BSIP are compared:

- anthropometric data proposed by [1] (**C0**);
- results of the BSIP calibration computed without any constraint on solids geometry (**C1**);
- results of the BSIP calibration computed with physiological constraints close to those used by [3] (**C2**). They consist in limiting the asymmetry and in limiting the BSIP variation from **C0**.

RESULTS AND DISCUSSION

Figure 1 shows the results of the different calibrations compared to the anthropometric data **C0**. First, it is easy to see that results of **C1** are completely inconsistent (the mass of the torso is very low compared to the other limbs, the symmetry is not respected). Results of **C2** seem more consistent with anthropometric data and correspond to the trends obtained by [3] (i.e. masses of torso and arms slightly lower than **C0** and masses of pelvis, head and legs slightly higher than **C0**).

Thus, even if the optimization is better in **C1** (in terms of cost function value), it appears to lead to overfitting. Additional physiological constraints are therefore essential in this BSIP calibration. Complementary studies have to be achieved to support these results. First, the BSIP calibration has to be tested with different morphologies especially with those distant of the 50th percentile. It allows to refine the choice of the physiological constraints to be added to the optimization problem. Secondly, obtained calibrated BSIP has to be compared with a ground truth estimation, for example with 3D scanning technologies.

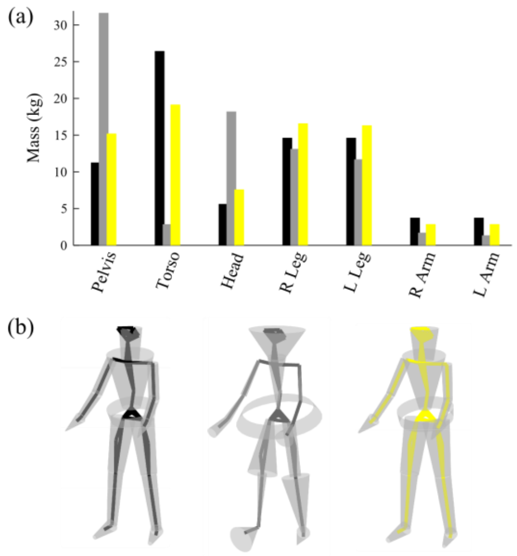

Figure 1: Results of BSIP comparison. (a) shows the mass of the different body parts; (b) represents the limbs BSIP, each assimilated to the close cone frustum in terms of BSIP. 1st result (black) is **C0**, 2nd result (grey) is **C1** and 3rd result (yellow) is **C2**.

CONCLUSIONS

The purpose of this study was to analyze the influence of additional physiological constraints on a BSIP calibration, based on an identification method. Results obtained without any additional constraint turned out to be inconsistent, revealing overfitting. Addition of physiological constraints, close to those used by [3], yields to more consistent results that have be thereafter validated with more accurate approach like 3D scanning.

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